Controller Design via Freq. Response

- **Proportional control (K only)**
  - desired phase margin related to damping ratio
  - desired static error constants adjusted by K

- **Lag controllers**
  - reshape low frequency response to obtain desired error constant with required transient response

- **Lead controllers**
  - reshape “high” frequency response to get desired phase margin

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**Problem #1a**

\[ \frac{K}{(s+2)(s+5)(s+8)} \]

Find K for a desired gain margin of 10 dB

\{ \text{Use Matlab™} \}
Problem #2b

Find $K$ for a desired phase margin of $40^\circ$

Use Matlab™

Lag Compensation

Steady-state error improves by $z_c/p_c$ ratio
What does the frequency response of the lag compensator alone look like?

Let $z_c=0.2$, $p_c=0.02$ as example.

Bode Plot of Lag Compensator
Problem #5

Find $K$ for a static error constant $K_v=50$, 15% overshoot and 2 second settling time

$15\% \text{ O.S.} \rightarrow \zeta \approx 0.52$

Bode Plot with $K=1$
Bode Plot with K=200

What do we want?

Keep phase the same, "push" the magnitude to 0 dB at ~3 rad/sec

Desired Phase Margin ~52°
Lag Compensator Design (p. 621)

- Set gain $K$ that satisfies steady-state error requirements and create Bode plot.
- Find frequency $\omega_+\,$ where $\Phi_M$ is $5^\circ$ to $12^\circ$ greater than the $\Phi_M$ required for desired transient performance.
- Select lag compensator with a combined Bode diagram that has $0\,$ dB at $\omega_+.$
- Adjust gain $K$ after lag compensator.

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**What do we want?**

- Desired Phase Margin $\sim 60^\circ$
- Keep phase the same, “push” the magnitude to $0\,$ dB at $\sim 2.5\,$ rad/sec.
Problem #5 - Solution

Desired static error constant $K_v=50$, 15% overshoot and 2 second settling time

Use Matlab™ to find the phase margin for the compensated system
Homework #17

• Due Friday, 11/19/99
• Work the following problems from Chapter 11 (pp. 640-641)
  1. Problem #1b
  2. Problem #3a
  3. Problem #6
  4. Problem #7